Chapter 3

HYDRO-MECHANICAL GOVERNORS, TYPE HMG.1 and HMG.2 SERIES

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Introduction

1. The governor HMG.1 consists of the hydro-mechanical governor only, whilst the HMG.2 also incorporates an overspeed control with amplifier valve and a rate re-set valve.

2. The hydro-mechanical governor provides a hydraulic reference pressure which is responsive to engine speed and is independent of the density of the fuel used in the system. This reference pressure can be applied in several ways to operate other mechanisms according to the purpose desired.

3. Applications of the governor are as follows:—

(1) As a simple overspeed control to limit maximum permissible engine speed by reducing the pump stroke through the pump servo system at a predetermined speed.

(2) As a range speed governor to limit engine speed in accordance with the degree of throttle opening over the upper portion of the engine speed range, the reference pressure being made to act upon a control unit subject to adjustment by a speed datum selector interconnected with the throttle lever.

(3) As a range speed governor to limit engine speed according to the throttle setting, by trimming a scheduling control system, and using the reference pressure to influence the controlling pressure-drop across the system.

(4) As a means of operating any engine accessories requiring a speed term in their operating characteristics.

4. The governor can be used for two or more of these applications simultaneously and can either be built into the high pressure fuel pump or fitted and driven independently as a separate unit.

Description

5. The principle of the governor is that of balancing the centrifugal force acting on a rotating mass by the pressure difference on a diaphragm, this pressure difference therefore being a measure of the speed of rotation.

6. Referring to fig. 2, engine fuel is introduced into the governor chamber through a restricting orifice and leaves the chamber through a valve which is actuated by the pivoted governor mass, the centrifugal force

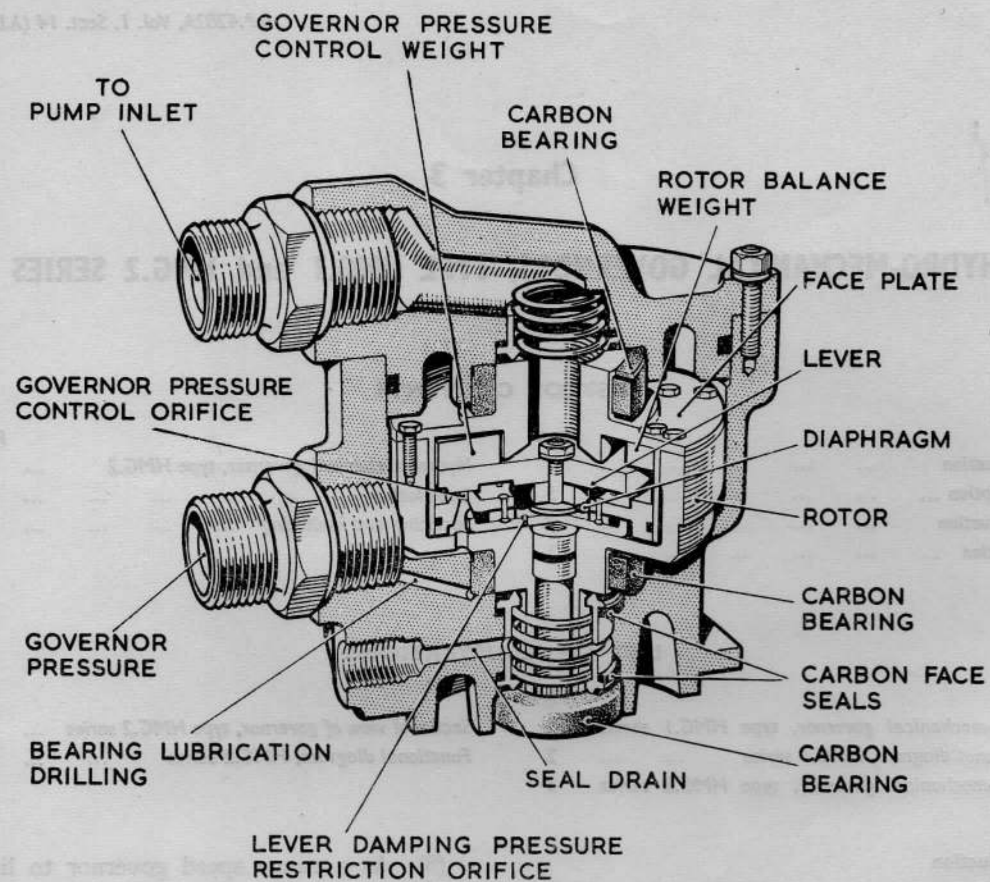

Fig. 1. Hydro-mechanical governor, type HMG.1 series

tending to close the valve. The pressure drop across this valve is applied to a diaphragm attached to the governor mass and tends to open the valve. As a result, the hydraulic force on the diaphragm is always in equilibrium with the centrifugal force on the mass and is hence a measure of this force and the corresponding speed. A connection is made from the governor chamber to the external circuit and furnishes a reference pressure difference which can be employed for any purpose requiring a speed term in the fuel system.

7. In order to be stable, the hydro-mechanical mechanism has to have a definite rate. This rate is put into the mechanism in two ways, both dependent on pump pressure:—

(1) By means of a pressure term which is applied to the kinetic lever or the effect of the servo pressure on the half-ball valve area.

(2) By a variation in flow which occurs due to changes of pump pressure on the feed to the hydro-mechanical governor chamber, this feed increasing with high pressure and decreasing with low.

Construction

8. The hydro-mechanical rotor is cup-shaped and is integral with its driving shaft. At the open end the rotor is sealed against the pressure in the surrounding chamber by a face plate and carbon-faced seal. In the opposite end, or base, of the cup is a web which is drilled to permit chamber pressure to pass to the control orifice and to the lever counterbalance diaphragm.

9. A carrier, bolted to the internal face of the rotor face plate, retains the control orifice, the control cantilever hinge and counterbalance diaphragm and also a weight which dynamically balances the control

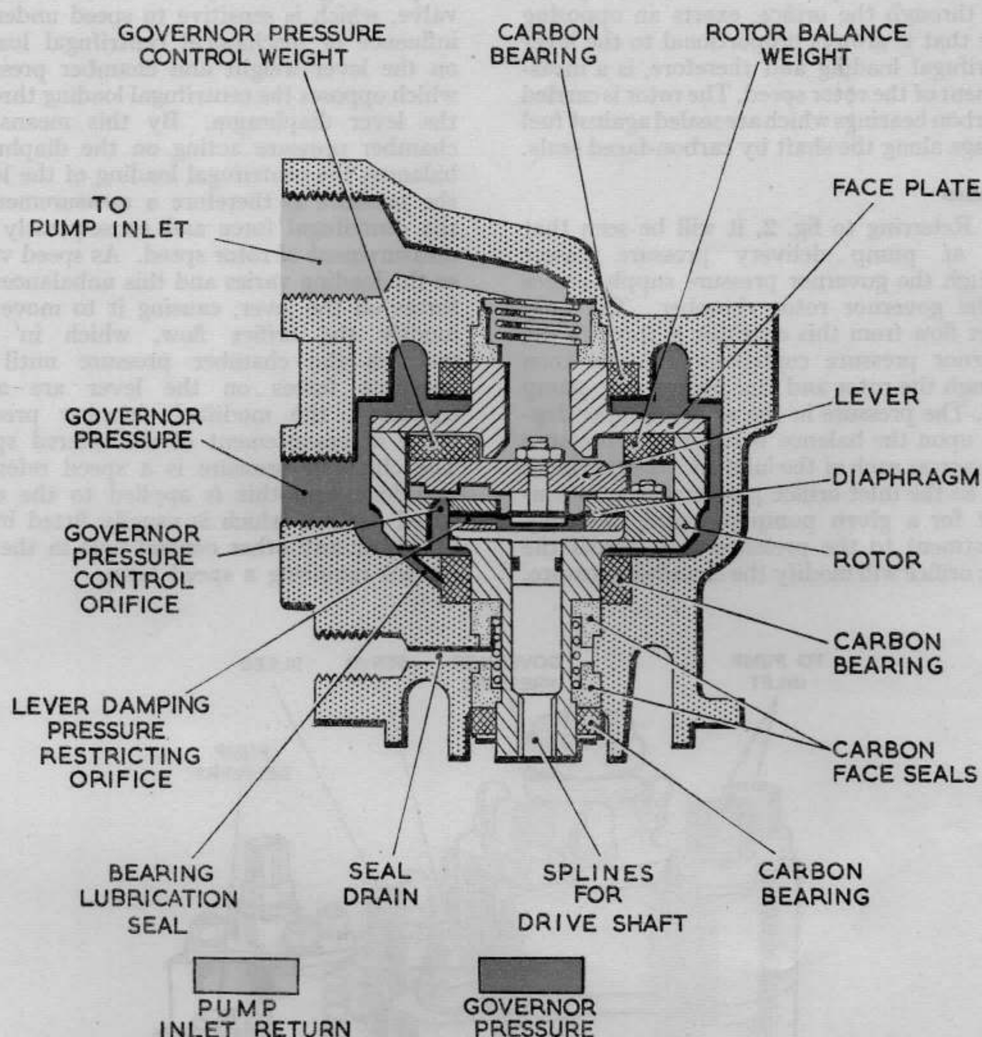

Fig. 2. Functional diagram, HMG.1 series

lever weight to ensure smooth running. The control cantilever leaf hinge secures one end of the lever, whilst the diaphragm is bolted at its centre to the centre of the lever and at its periphery to the bottom face of the carrier. A space beneath the diaphragm is enclosed by an orifice plate which allows fuel to pass from slots in the inner face of the rotor web to the diaphragm face. This orifice plate permits the chamber pressure to be sensed fully by the diaphragm, but by restricting the flow to and from the diaphragm, damps out any tendency of the control lever to vibrate under adverse conditions.

10. The control cantilever lies across the rotor diameter and is arranged to swing in the line of the rotor axis. At its free end the lever carries a weight on its upper side, the weight centre of gravity being offset from the plane of the leaf hinge; the lower surface of the lever immediately beneath the weight forms the valve which regulates the flow through the control orifice. Under operating conditions the weight centre of gravity tends to swing towards the plane of the hinge, so that this end of the lever is moved towards the orifice to restrict the flow; the degree of movement is restricted only by the influence

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of the counterbalancing diaphragm which, under chamber pressure controlled by the spill through the orifice, exerts an opposing force that is always proportional to the lever centrifugal loading and therefore, is a measurement of the rotor speed. The rotor is carried in carbon bearings which are sealed against fuel leakage along the shaft by carbon-faced seals.

Operation

11. Referring to fig. 2, it will be seen that fuel at pump delivery pressure passes through the governor pressure supply orifice to the governor rotor chamber. The only outlet flow from this chamber is through the governor pressure control orifice and then through the rotor and face plate to the pump inlet. The pressure in the rotor chamber depends upon the balance between the pressure drop across each of the inlet and outlet orifices and, as the inlet orifice pressure-drop is constant for a given pump pressure, then any adjustment to the pressure drop across the rotor orifice will modify the chamber pressure.

12. In operation the control orifice pressure drop is regulated by the rotor cantilever valve, which is sensitive to speed under the influence of mechanical centrifugal loading on the lever weight and chamber pressure, which opposes the centrifugal loading through the lever diaphragm. By this means the chamber pressure acting on the diaphragm balances the centrifugal loading of the lever; the pressure is therefore a measurement of the centrifugal force and consequently is a measurement of rotor speed. As speed varies so the loading varies and this unbalances the forces on the lever, causing it to move and modify the orifice flow, which in turn modifies the chamber pressure until the opposing forces on the lever are again equalized, the modified chamber pressure being a measurement of the altered speed. The chamber pressure is a speed reference therefore, and this is applied to the overspeed control, which is usually fitted in the pump, or any other control unit in the fuel system requiring a speed term.

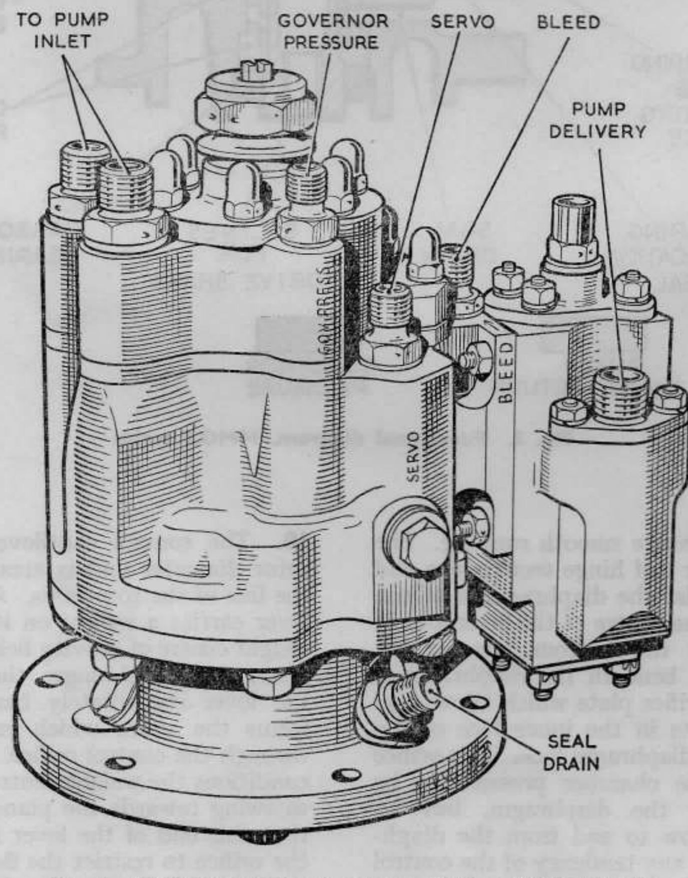

Fig. 3. Hydro-mechanical governor, type HMG.2 series

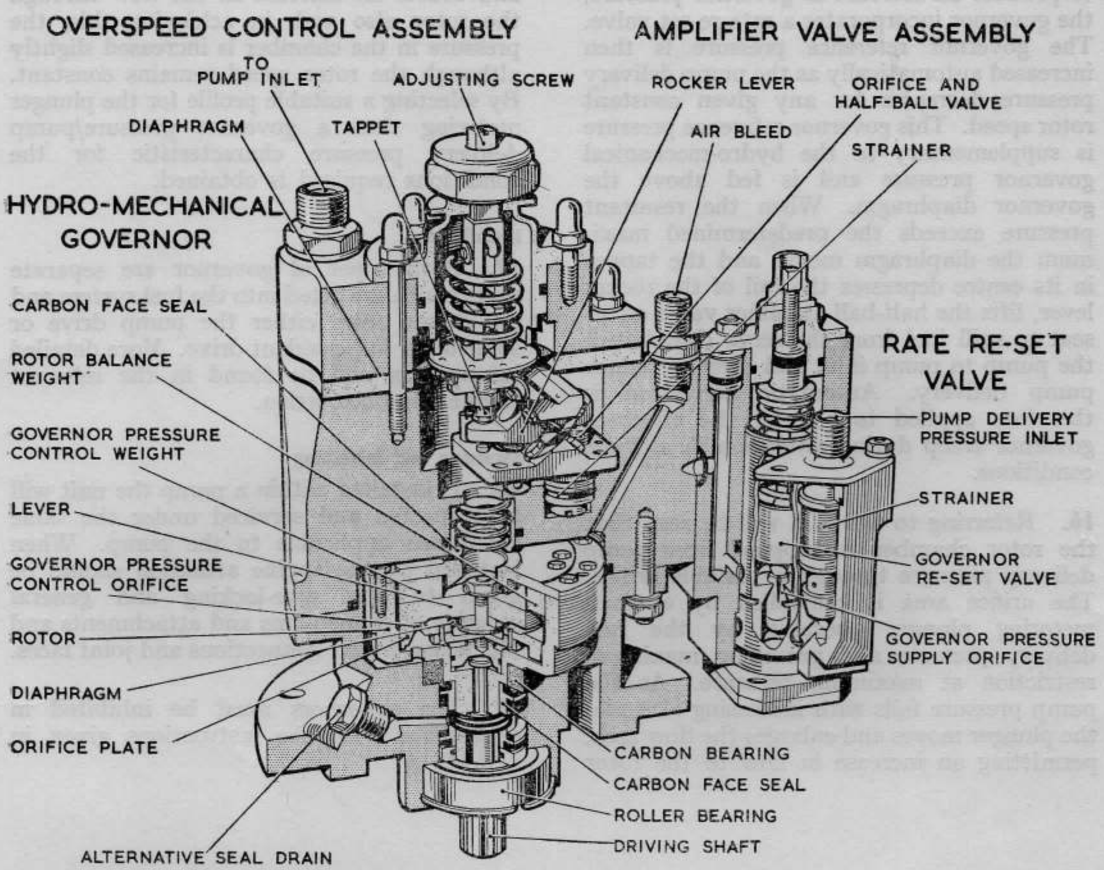

Fig. 4. Sectional view of governor, type HMG.2 series

Hydro-mechanical governor, type HMG.2

13. An overspeed control is built into this unit and comprises the normal diaphragm adjusted by spring pressure and subject to governor pressure on one side and pump inlet pressure on the other. A tappet in the centre of the diaphragm contacts the tail end of the rocker lever (which forms part of the amplifier valve assembly) and which houses at its other end a half-ball valve which seats on an orifice in communication with the servo chamber of the pump. The hydro-mechanical governor itself is similar to that described in the preceding paragraphs.

14. In order that an overspeed control may be stable, it is necessary for it to have a certain rate, i.e., a given reduction in fuel flow through the burners due to governor action must be accompanied by an increase in engine speed. A reduction in fuel flow is felt by the pump as a reduction in pump delivery pressure and to provide the necessary stabilizing rate it is arranged that the overspeed assembly shall be responsive to both governor pressure and pump delivery pressure, i.e., a decrease in delivery pressure requires an increase in governor pressure to preserve equilibrium. Consequently, if the overspeed assembly is set to govern the engine speed at ground level, for a given pump delivery pressure, then at altitude, when the delivery pressure is much lower, due to altitude control effects, the engine governed speed must be correspondingly higher, i.e., the governor must run to a higher speed to produce the necessary increase in governor pressure to counter the reduction in delivery pressure effects. This difference in speed is known as governor creep.

15. Instead of requiring an increase in speed to produce an increase in governor pressure, the governor incorporates a rate re-set valve. The governor reference pressure is then increased automatically as the pump delivery pressure decreases for any given constant rotor speed. This governor reference pressure is supplementary to the hydro-mechanical governor pressure and is fed above the governor diaphragm. When the resultant pressure exceeds the predetermined maximum the diaphragm moves and the tappet in its centre depresses the tail of the rocker lever, lifts the half-ball amplifier valve off its seat to spill fuel from the servo chamber of the pump to pump inlet and thereby reduce pump delivery. Automatic correction is therefore applied to counter the effect of governor creep during alteration in altitude conditions.

16. Referring to fig. 5, it will be seen that the rotor chamber is supplied from pump delivery pressure through a variable orifice. The orifice area is controlled by a small metering plunger operated by the fuel delivery pressure and providing maximum restriction at maximum pressure. As the pump pressure falls with increasing altitude, the plunger moves and enlarges the flow area, permitting an increase in flow to the rotor chamber; this influences the rotor diaphragm and causes an increase in the flow through the rotor also and, in achieving this, the pressure in the chamber is increased slightly although the rotor speed remains constant. By selecting a suitable profile for the plunger metering slots a governor pressure/pump delivery pressure characteristic for the conditions required is obtained.

Installation

17. Both types of governor are separate units which are fitted into the fuel system and are driven from either the pump drive or some other independent drive. More detailed information will be found in the relevant engine Air Publication.

Servicing and inhibiting

18. If installed within a pump the unit will be inspected and serviced under the same conditions applicable to the pump. When installed on the engine attention should be given to any wire-locking and general security of connections and attachments and fuel leakage from connections and joint faces.

19. The governors must be inhibited in accordance with the instructions given in A.P.4471A.

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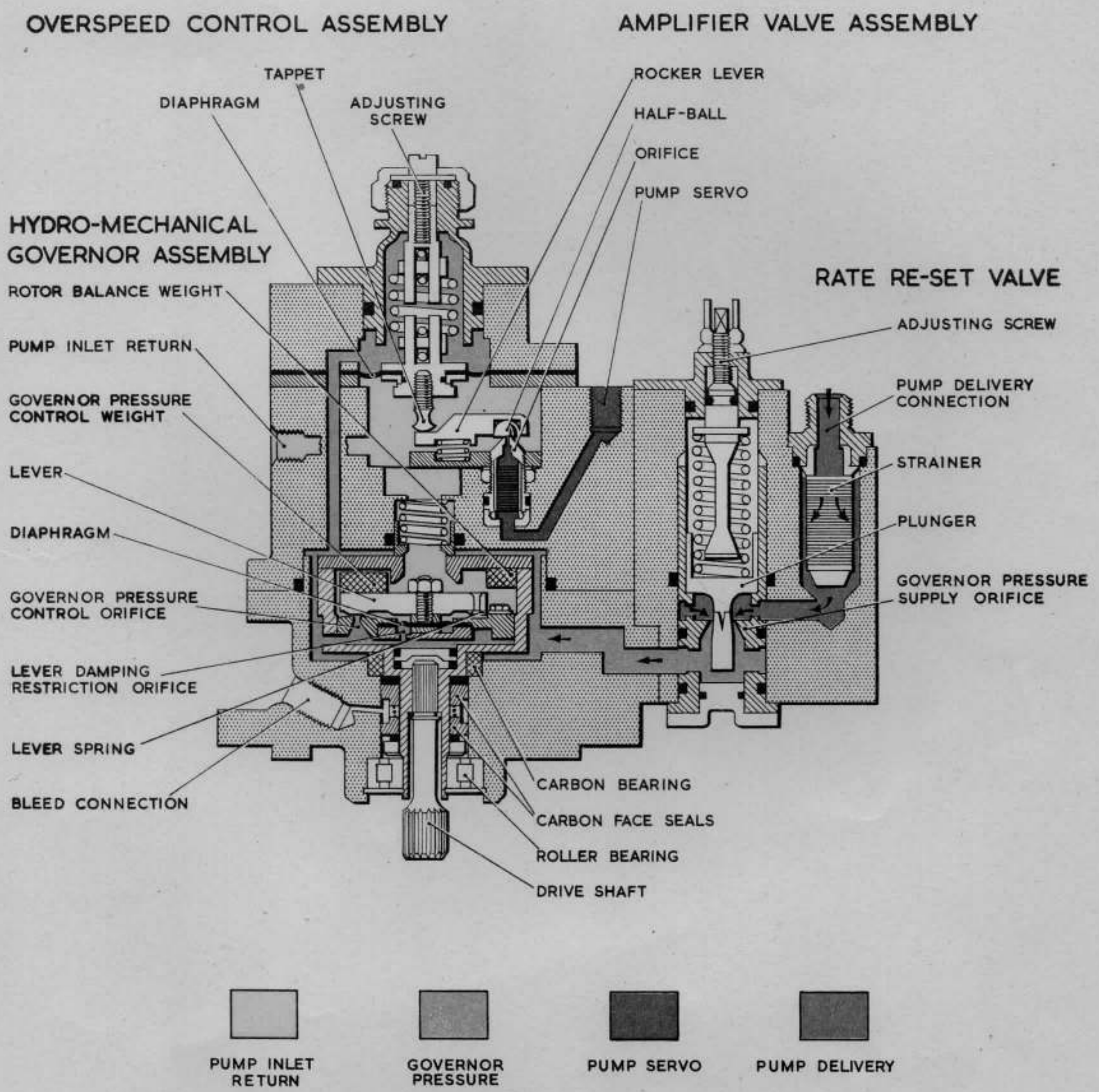

Fig. 5 Functional diagram, HMG 2 series

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